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COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

NATIONAL RESEARCH ON SPACE DEBRIS

SAFETY OF NUCLEAR-POWERED SATELLITES

PROBLEMS OF COLLISIONS OF NUCLEAR-POWERED SOURCES WITH SPACE DEBRIS

Note by the Secretariat

Addendum

1. The Secretary-General addressed a note verbale, dated 13 July 1994, to all Member States inviting them to communicate information on national research on space debris, safety of nuclear-powered satellites and problems of collisions of nuclear-powered sources with space debris.

2. The present document contains information provided in replies received from Member States between 8 and 24 February 1995.

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REPLIES RECEIVED FROM MEMBER STATES

FRANCE

[Original: French]

A. Space objects: state of the art

During the first few years of the space era, meteorites were the only potential hazard in the environment. Since then there has been considerable development of human activity in space and this has introduced an additional difficulty with the emergence of artificial debris. Presently, the means of observation from the ground have listed approximately 7,000 objects greater than 10 cm in size. This list includes some 350 satellites in operation and 1,500 disused satellites, the remainder applying to debris from the stages of launching, explosion and disintegration of satellites.

In the long run research workers and technicians would know how to solve the problem if the catalogue of artificial objects in space were certain to represent the amount of debris to be monitored and to be avoided in the case of space missions. Unfortunately, measurement techniques are still limited. They are only usable for low orbits, up to about 1,000 km. Beyond that, for example for the geostationary orbit located at 36,000 km, the present observation techniques can only detect objects more than a metre in size. There is still uncertainty regarding, among other things, particles stemming from fragments of paint and solar cells. Several retrievable missions such as the Long Duration Exposure Facility (LDEF) or the European Retrievable Carrier (EURECA) have made it possible to evaluate the size of particles and their effects to some extent. On the basis of statistical models it is believed that several thousands of particles of debris are spread around the Earth and that those located at altitudes above 800 km will stay there for several centuries, if not several millennia.

The basic danger stems from risks of collision. The very high speed of these particles, which is of the order of several kilometres per second, produces an energy impact which may be considerable, making the present shielding of satellites totally ineffective. With the present technologies, the shielding no longer has any effect in the case of debris greater than 0.5 cm in size. Hence a collision could seriously endanger, if not destroy, a satellite.

In France, the National Space Research Centre (CNES) has been studying the problem for several years and a group of experts has been set up who are responsible for researching the problem and proposing and following up a programme of activities on the subject. The work undertaken relates, inter alia, to the acquisition and interpretation of data relating to the space debris environment.

B. Activities in France

CNES, in consultation with the French laboratories involved, has acquired modelling equipment in order to better grasp the problem and plans to pursue research in the area of evaluation and improvement of mathematical models describing the flux of debris in space.

Means of observation

Project ROSACE

This project, currently under development by CNES, seeks to improve the way in which the orbit of satellites in geostationary orbit can be determined by measurements from the ground. The system combines a Newton telescope and a charged couple device (CCD) matrix. The point of it is to measure the angular separation between the image of the satellite's trajectory and that of sufficiently well-known stars. The

measurements are dated using a Global Positioning System (GPS) receiver. Measurement accuracy is 0.1 arc second and 1 ms in time. Integration of the prototype used for this experiment will start during the present year. By making a number of improvements, among others enlarging the instrument angle of view and the processing of the images, this experiment could be adapted to suit the case of space debris.

Synoptic Monitoring of Orbital Debris

The Synoptic Monitoring of Orbital Debris (SYNMOD) project, carried out by the Institute for Space Science and Technology (ISST Europe), located at Grasse Magagnose in France, in collaboration with several laboratories and institutes, is supervised by European and American organizations. Its aim is to acquire better knowledge of the space debris environment. CNES has been interested in the case of the geostationary orbit and also transfer orbits and has taken part in two basic projects:

(a) A ground observation programme: the observations are conducted with the Calern observatory which uses a telescope fitted with a CCD camera. An observation campaign lasting three months is planned in order to verify whether the observation site and the measuring devices are really suitable;

(b) Calibration of detectors: observations are to be conducted in orbit using a new type of capacitive detector that can measure the mass and velocity of the particle that has caused the impact. At the beginning ground experiments will be necessary in order to assess the efficiency of this type of detector.

Other means

During the next few years, projects involving military systems for observing territory, which are being gradually put into effect, such as the Major Network Suited to the Space Watch (GRAVES) project, will be able to provide information of use in the location of objects for the case of low orbits.

Measurements in space

Retrievable missions, such as the LDEF and EURECA satellites or the flights on board the Russian space station MIR, also provide interesting information on the population of debris in low orbits.

CERT ONERA (DERTS) has undertaken a set of analyses on the passive detectors carried aboard the LDEF satellite that was launched in April 1984 into an orbit at 476 km and recovered 86 months later by the space shuttle Columbia, and on the EURECA satellite launched in 1992 into an orbit at 525 km inclined at 28.5° and recovered 11 months later. The idea was to measure the flux, size, radial distribution and composition of the microparticles located in these orbits. Similar studies have been undertaken at the CNES expert laboratories and the results are helping to improve mathematical models on particle flux.

MIR, placed in an orbit between 350 and 450 km and inclined at 51.6°, will carry out the European Science Exposure Facility (ESEF) experiment this year as part of the Euromir 95 mission, by which it will be possible to expose detectors and samples. The mission, which provides for trips into space to set up and retrieve the experiment, is part of the cooperation between the European Space Agency (ESA) and the Russian space agency RKA. CERT ONERA (DERTS), in collaboration with CNES, has planned to use passive detectors. The method is the same as the one employed for the experiments previously described. It consists of using metal targets and multilayer detectors. This will make it possible to improve knowledge of the debris in the neighbourhood of the orbit, to study the degradation of materials impacted on by high-velocity particles and to evaluate the effects of synergy with the other space environment components such as atomic oxygen and ultraviolet radiation.

Trajectory calculation

Natural re-entry

In a low orbit, residual atmospheric density brings about a decrease in the altitude of a satellite which speeds up as it approaches Earth. When the satellite re-enters the dense layers of the atmosphere, it burns up. Nevertheless, certain sizeable pieces may reach Earth, entailing risk in inhabited areas. Hence it is important to be in a position to foresee the moment of impact and to locate the area involved with accuracy. To this end, CNES has developed a model for predicting re-entry based on NORAD data.

Access to the Database and Information System Characterizing Objects in Space

The Database and Information System Characterizing Objects in Space (DISCOS), which was established by ESA, contains information on observable space objects. Its use is essential for dealing with the problems posed by space debris. Hence CNES has undertaken to exploit the opportunities offered by this database. A catalogue listing the objects from French missions and the Ariane launcher has been drawn up. So far this list has identified 167 objects ranging from disused satellites to simple debris, 90 per cent of which are still in space.

In order to allow for the risks of collision between these objects and a satellite during the present missions or those to come, a model has been developed that identifies the orbits at risk.

Modelling

Modelling the explosion of launchers

The explosion of a launcher on the launching pad or during the launching stage may give rise to a scattering of the debris that the flight safety officer should know how to evaluate and monitor. This is why CNES has come round to the idea of developing a deterministic prediction model, called SEDIA, in order to predict the hazardous areas around the launching zone. In this way, it can be decided whether to voluntarily destroy the launcher if it deviates from the safety perimeter during the initial stages of the flight. This deterministic approach to the problem proceeds in stages, with evaluation of the explosion energy and calculation of the ejection velocity, fragment trajectory and fallout areas.

Models for the directivity of meteorite fluxes

There is presently a study aimed at analysing and modelling the directivity of meteorite flux in the terrestrial and interplanetary environment. Existing models based on experimental results do not provide information on the direction of the impact. Hence the objective is to calculate the trajectory of the particles as well as their velocity. The problem will be dealt with by considering the particles not as independent objects but as a group with a density that can be approached by mathematical modelling. In this way it is possible to calculate the distribution function and to estimate certain parameters such as flux and density. A second stage will be necessary to optimize this theoretical approach by comparison with available experimental data.